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CLASSIFICATION OF THE MISSISSIPPIAN SERIES.

Because of its vast array of finely preserved fossil forms, the Mississippian or Lower Carboniferous limestone series, has, since the beginning of geologic investigation in the Mississippi valley, aroused great interest. At an early date the fossils of the successive beds were studied, and were illustrated in the geological reports of Iowa, Illinois, and Missouri, and formation names were given to the various strata. In the final adjustment of the work of all the earlier investigators, the following formation names, from the base upward, came to be recognized, (1) Kinderhook, (2) Burlington, (3) Keokuk, (4) Warsaw, (5) St. Louis, and (6) Kaskaskia or Chester. Each one of these divisions was held to be of equal importance with all the others, essentially, and until recently this original, more or less artificial, classification remained in vogue.

The true classification of rock strata and fossil faunas is but an incident in the elaboration of the geologic history of a region, and in order to make a natural classification of these phenomena, they must be considered from a historical standpoint. The classifications of rock strata which have been generally used, are based upon two distinct sets of criteria, (1) stratigraphic, and (2) faunal. A stratigraphic classification by no means excludes the fossil evidence, and is based fully as much upon the differences observed among the fossil species of successive formations as upon the physical characteristics of the strata; but the fossils are looked upon in the same light as the physical characters, as a sort of label of the strata, rather than as a real life element subject to all the laws of organisms. The old classification of the Mississippian series into the six formations indicated above was purely stratigraphic in its nature, although great stress was laid upon the fossil contents of the various formations.

It is a universally recognized fact today, that assemblages of organisms are intimately related to the environment in which they live. With a change in the environment there will be changes among the associated organisms.

In no geologic province, such as the continental interior of North America during Carboniferous time, whose history must be considered as a unit, are the physical conditions of the whole area identical at any given time. Neither are the conditions of any one limited portion of the province, identical throughout an entire epoch or chapter in its history. Local changes in the physical conditions, and consequently in the local assemblages of organisms are continually in progress. A stratigraphic classification of rock strata is based upon these local changes in the sediments and their contained organic remains, and consequently can be of but local significance. In such a classification the profound physical changes which affect the whole geologic province in its relations with adjacent provinces, are given no greater importance than the comparatively insignificant local changes.

A natural classification of strata must be a faunal classification in its broadest sense. It is based not merely upon the identity or lack of identity of fossil species in the different local formations, but upon the minute study of the relationships of the assemblages of fossils in the successive zones of particular sections, and upon the study of the geographic distribution of species. All fossil species are either indigenous or exotic to the geologic province in which they are found preserved. They are either evolution species or immigration species, and the sudden appearance of exotic or immigration species in the fauna of a geologic province, shows, as nothing else can show, that the relationship between the province and its neighbors is undergoing a readjustment. In the history of any geologic province the distinct epochs or chapters must be limited by these periods of readjustment. Oftentimes these periods cover a considerable lapse of time and alternate with periods of quiet, in which case the periods of change and the periods of quiet are most naturally considered as distinct epochs.

A name applied to a historical epoch of a geologic province, is applicable as a stratigraphic name to all the strata deposited during that epoch. It may not always be possible to draw a sharp and fixed line in the stratigraphic series between two succeeding epochs, so that everywhere, throughout the geologic province the exact limits of the historical epochs may be pointed out. It is not necessary, for the establishment of an epoch name, to select, as the type, a section in which every stratigraphic and faunal phase of the epoch is illustrated. As a matter of fact it would be almost impossible to find a type section for most geologic epochs in which all its varied phases were exhibited. It is only necessary, in the selection of a geographic name for a geologic epoch, that some one or more phases of strata and fauna be well illustrated there.

In recent years, two classifications of the Mississippian series have been proposed. The first by Williams[1] is a natural faunal classification, while the second by Keyes[2] is a stratigraphic classification which is nothing more than a further elaboration of Hall's earlier one, uniting some of his divisions and dividing others.

Williams was the first to recognize in the strata and fossil faunas of the Mississippian series, the evidence of three distinct chapters in the history of the continental interior during lower Carboniferous time, and for these chapters or epochs he used the names (1) Chouteau, (2) Osage, and (3) Ste. Genevieve. The commonly recognized local geologic formations were placed, as accurately as was possible at that time, in their respective epochs, and further investigation seems to necessitate no different disposition of them. Of the three epoch names proposed, Osage and Ste. Genevieve were used for the first time. Chouteau, on the other hand, had long been used as a formation name for one of the local limestone strata in Missouri. The Chouteau group was made by Williams to include, beside the Chouteau limestone, several other local formations, and as the relationship between the faunas of these formations had previously been recognized, and the name Kinderhook applied to them all, it seems best to use the latter name instead of Chouteau for the first epoch.

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[1] Bull. U. S. G. S., No. 80, p. 169.

[2] Bull. Geol. Surv. A., Vol. III, p. 283; Iowa Geol. Surv., I, p. 50; and Missouri Geol. Surv., IV, p. 76.

In order to have a right understanding of the history of the continental interior during Mississippian time, it will be necessary to glance briefly at the events immediately preceding During the greater part of Devonian time, the eastern interior region of North America was occupied by the great Mediterranean Appalachian sea. This sea extended from the Laurentian land on the north to the western extension of the Appalachian land[1] on the south, and from the Appalachian on the east to the Missouri land on the west. The outlines of this sea were continually changing during Devonian time, and at intervals it was joined by open passages in different directions with the outer oceans. Near the close of the Hamilton epoch, a passage through the northwestern portion of North America was opened, by means of which communication was established between the Appalachian sea, and the Eurasian ocean. This northwest passage crossed northern Missouri, Iowa, and southwestern Minnesota, and extended northward through Manitoba and the Mackenzie Valley. The Chemung fauna of the Appalachian province contains an important element derived from the European faunas, an element which without doubt found its way into the Appalachian sea through this northwest passage.

Just before the opening of Mississippian time, the distribution of land and water in North America was about as indicated in Fig. A, the northwest passage being connected with the Eurasian province. The progress of events during the period was, first, an epoch of disturbance, of readjustment and sinking land; second, a long epoch of quiet and equilibrium, with widespread marine conditions; and third, another epoch of disturbance with further readjustment between the interior province and its neighbors. These three epochs are: the Kinderhook, Osage and Ste. Genevieve.

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[1] Proc. Bost. Soc. Nat. Hist., XXVI, p. 474; and A. J. S. (4), IV, p. 357.

The stratigraphic elements included in the Kinderhook group are varied in their physical characteristics. There are limestone, sandstone and shale formations. The formations are local in their distribution and characters, and consequently the different minor assemblages of organisms preserved in the strata are more or less local in their distribution. The Kinderkook fauna as a whole is known only in a very general way, no detailed investigation of it has ever been attempted. It is in many respects related to the Devonian faunas, and especially to that fauna which had found its way into the region from the northwest.

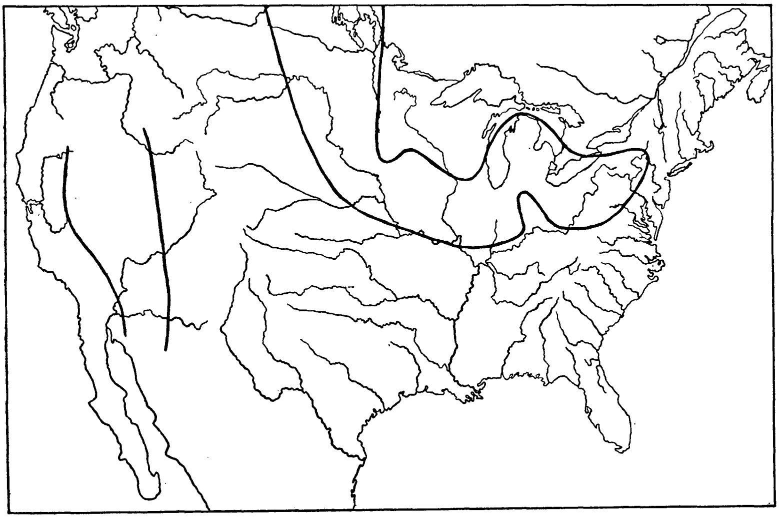

FIG. A.

During the progress of the Kinderhook epoch the land was sinking to the south, and the southern shore line was migrating in that direction. The margins of the successively younger sediments transgressed further and further to the south over the ancient land surface. In central Missouri, strata of late Devonian age rest directly upon the old Ordovician land surface. In southern Missouri, strata of Kinderhook age occupy the same position, and in central Arkansas, in the region of the Ouchita uplift, the whole Mississippian series is absent, strata of Lower Coal Measure age resting upon the Ordovician beds.

The Kinderhook epoch of generally disturbed conditions, the epoch of readjustment, was followed by the Osage which was a long period of tranquillity. No longer were there sediments of various sorts being deposited in the interior sea. The surrounding land had sunk so low that practically no sediments were transported by the streams, and the only rock-making material furnished was the calcareous secretions of organisms. Crinoidal fragments constitute the major portion of this limestone, though the remains of corals and brachiopods are also abundant.

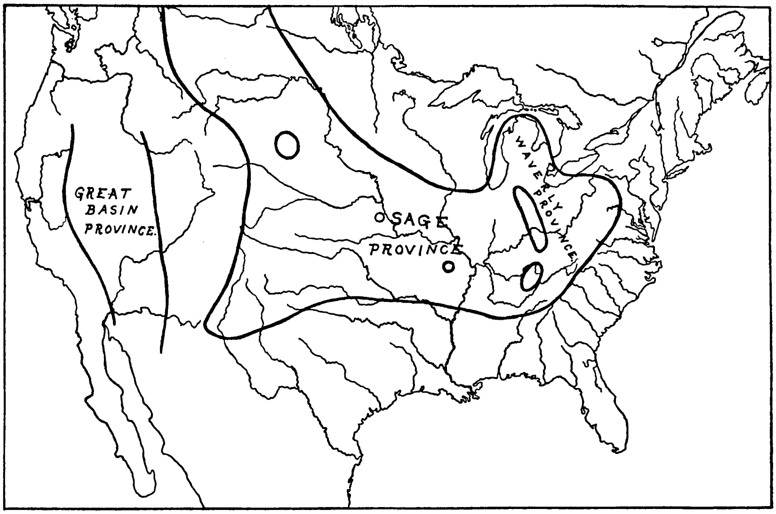

FIG. B.

The probable distribution of land and water during Osage time is indicated in Fig. B. A great, quiet, interior sea extended from the Cincinnati island on the east to the Rocky Mountain land on the west, and from the southern Appalachian land to the Wisconsin land at the north. The northwest passage still furnished a means of communication with European waters.

The Osage is the best known of any of the Mississippian aunas. Hundreds of species of crinoids founded upon the most perfectly preserved specimens in the world have been described from these strata. Next in importance to the crinoids are the brachiopods, represented by many species. Besides these the corals and bryozoa are often abundant, but the remaining classes of organisms are relatively inconspicuous. The fauna has been most studied in Iowa, Illinois, and Missouri, but a good, crinoidal, Osage fauna has been described from southwestern New Mexico,[1] and crinoids certainly indicating the presence of the fauna have been described from near Bozeman Mountain.[2]

The Osage fauna has many points of resemblance with the fauna of the mountain limestone of western Europe. In each there is a large crinoidal and a large brachiopod element. Every genus of crinoids in the European fauna is represented in the American, and many species of brachiopods are common to both regions, though the American specimens have sometimes been given different names. The following is a partial list of identical or representative brachiopods in the two regions:

American species	European species
Athyris incrassatas H.	*Athyris roissyi* L'Eveille.
A. lamellosa L'Eveille	*A. lamellosa* L'Eveille.
Camarophoria subtrigona M. and W.	*Camarophoria isorhyncha* McCoy.
Chonetes illinoiensis Worthen.	*Chonetes hardrensis* Phill.
Dielasma hastata Sow.	*Dielasma hastata* Sow.
Dielasma sacculus Martin.	*Dielasma sacculus* Martin.
Leptæna rhomboidalis Wilck.	*Leptæna analoga* Phill.
Orthis (*Rhipidomella*) *burlingtonensis* H.	*Orthis michelini* L'Eveille.
O. (*Schizophoria*) *swallovi* H.	*O. resupinata* Martin.
Productus laevicostus White.	*Productus cora* D'Arb.
P. punctatus S. Martin.	*P. punctatus* Martin,
P. burlingtonensis H.	*P. semireticulatus* Martin.
Rhynchonella pleurodon Phill.	*Rhynchonella pleurodon* Phill.
Spirifer grimesi H.	*Spirifer striatus* Martin.
S. Logani H.	

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[1] A. J. S. (3), XXVII, p. 97.

[2] Bull. Ill. State Mus. Nat. Hist., Nos. 10 and 12.

American species.	European species.
S. lineatus Martin.	*S. lineatus* Martin.
S. lineatoides Swall.	
S. pseudolineatus H.	
S. suborbicularis H.	*S. ovalis* Phill.
S. tenuimarginatus H.	*S. duplicicostus* Phill.
Syringothyris carteri H.	*Syringothyris cuspidatus* Martin.

The similarity between the faunas of the two regions is so great that some way of intercommunication must have been in existence. The presence in Grinnell Land[1] of a similar fauna, in some respects intermediate between the two, would seem to indicate a northern and then eastern passage-way between the interior American province and western Europe.

The physical changes, which initiated the interior continental province of Osage time, were of a different nature from the changes that had ushered in previous epochs in the history of the region; and as a consequence, the fauna of the Osage epoch falls into a different category from earlier ones. In no case were the changing faunas of the Appalachian province during Devonian time, to any great extent, indigenous in their origin. The Osage fauna, however, was apparently very largely native to the region. The western European faunas doubtless exercised their influence upon it, but the influence of the American fauna upon that of Europe seems to have been much the greater.

A large portion of the territory occupied by the Osage province had previously been dry land. A vast area of new sea bottom was formed by the sinking of the land. The marine organisms which were to inhabit the region were unhindered in their development. They came in contact with no previously existing fauna which had either to be driven out or to be absorbed into their own social organization. Their rapid growth and differentiation may be compared with the rapid development of a human civilization in a newly opened country with vast resources, where there is a place for everyone with strength and vigor, and where the close struggle of individual with individual does not exhaust the vitality. While the close struggle for existence between individuals does seem to be a means of bringing about many minor differentiations of specific importance, the more important differentiations of generic or higher rank seem to be associated with conditions under which there is a wealth of resources, where the struggle is between the organism and the physical environment to a greater extent than between organisms and their nearly related fellows.

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[1] Q. J. G. S. Lond., XXXIV, p. 568.

The characteristic features of the Osage fauna were assumed at its beginning. After this the struggle was to a greater extent between individuals, and the organic changes were of minor importance, being to a great extent of no more than specific rank.

That the influence exerted by the American fauna upon that of western Europe was greater than the influence of the European upon the American fauna, is shown by a comparison of the crinoidal elements of the faunas in the two regions. In the Osage faunas of America 50 genera of crinoids are recognized, and in the equivalent faunas of western Europe 21 genera. Of the European genera not a single one is peculiar to the region, each being also represented in America. On the other hand 29 genera are peculiar to the American fauna. Furthermore, of the genera which occur both in America and in Europe, a larger number of species are known in America than in Europe. These facts seem to show that as between the two the point of origin or of major distribution of this crinoidal fauna was in the continental interior province of America, and that in the course of its existence it probably migrated from this province into other regions.

During the time when the broad expanse of the clear waters of the Osage sea was the most conspicuous feature of North America, there were in existence at least two other and smaller geologic provinces in which different physical conditions prevailed, and which were inhabited by very different assemblages of organisms. The first of these, the Waverly, lay to the east of the Osage province, between the Cincinnati island and the

Appalachian land, and extended from Michigan through eastern Ohio and western Pennsylvania south to the Ohio River. There was direct communication between this and the western Osage province, and during the Kinderhook epoch there was a considerable community of faunas, but at no time did the clear water conditions of the Osage sea extend into the Waverly gulf. Consequently the clear water Osage species did not generally flourish in the Waverly province, though enough have been recognized to show that the Waverly series is practically the equivalent of the formations of the Kinderhook and Osage epochs combined.

While the interior of the continent was sinking and the Osage sea was spreading out towards the Rocky Mountain land, the land on the northeastern border remained well above sea level. Under these conditions abundant clastic sediments were continuously furnished to the northeastern Waverly gulf, but the long Cincinnati island extending north and south across its mouth prevented the spreading of the sediments into the clear waters of the Osage sea beyond.

In the western part of the North American continent, lying between the Rocky Mountain land on the east and the Californian land on the west, was the Great Basin province. In this province there had been no important change in the passage from Devonian to Carboniferous time. While in the interior of the continent there was but a short interval, the Kinderhook epoch, during which an apparent mingling of Devonian and Carboniferous species is observed, in the Great Basin province Devonian species continued to live, associated with others of Carboniferous types, long after they had disappeared in the Osage province.

Following the prolonged quiet of the Osage epoch in the interior, there was another long period of readjustment and change, which culminated in the elevation of the greater part of the region previous to the deposition of the widespread millstone grit formation which initiated the Coal Measures. This was the Ste. Genevieve epoch. In the far west the barrier between the Great Basin and the interior provinces was submerged, allowing the incursion of the Great Basin fauna with its persistent Devonian species into the interior. This recurrent Devonian element in the faunas of the interior, first definitely recognized in the Spring Creek limestone from near Batesville, Ark.,[1] is the faunal mark of the initiation of a new chapter in the geologic history of the continental interior. This element is characteristic of the St. Louis fauna wherever it exists. One of the best known of the St. Louis limestone faunas is that of the Spergen Hill beds in Indiana, and in this fauna the recurrent Devonian element is recognizable in the species of *Microdon*, *Conocardium* and *Nuculana*, genera which had disappeared from the interior of the continent during the Osage epoch. Although the Spring Creek and Spergen Hill faunas are quite different in many minor details, they possess many species in common, showing their relationship. In addition to this resemblance of the Spergen Hill fauna to the Spring Creek fauna, which is closely allied to the Great Basin fauna, a fauna practically identical with that of the Spergen Hill beds has been recorded from the far northwest in Idaho,[2] an occurrence which suggests the possibility of its immigration into the interior from that direction.

During the latter part of the Osage epoch there was apparently an emergence of the northern shore line in the region of Iowa, because the younger beds of the Osage group do not extend so far north as the older ones. With the beginning of the Ste. Genevieve epoch, however, this was all submerged again, and the St. Louis limestone strata extended farther to the north than the immediately preceding ones. This submergence was followed by a considerable reëlevation at the north, the Kaskaskia beds being deposited only in the southern portion of the province. The successive changes, more or less abrupt, in the sediments of the Ste. Genevieve group from limestone to sandstone, to shale and back again to limestone, etc., indicate

[1] Am. Jour. Sci., XLIX, p. 94.

[2] A. J. S. (3), V, p. 383.

that rapid and relatively violent local changes were in progress throughout this whole period of readjustment.

The fauna of the Ste. Genevieve epoch in all its varied phases is but imperfectly known, but it apparently contains, throughout, in greater or less degree, the western element suggestive of the prolonged Devonian, which first makes its appearance in the St. Louis limestone fauna, and continues on even into the faunas of the Coal Measures.

In the geologic history of our continent during Mississippian time, many details remain to be elaborated, and with the elaboration of these details our conception of it may be altered in some respects. It is believed, however, that further investigation will but make clearer the general features as outlined here. The threefold classification of the Mississippian strata, based upon the actual geologic history of the region as told by the fossils and by the geographic evolution, is seemingly the only natural one.

An attempt has recently been made[1] to substitute the name Augusta for Osage. The two names have been proposed for practically the same stratigraphic series, but in their proposal the two authors seem to hold very different conceptions of the criteria which should be used when the classification rises above the mere grouping of beds of a local character. The name Osage was proposed for a definitely recognized chapter in the geologic history of the region under consideration, while Augusta was proposed as the name of a special stratigraphic division composed of certain local formations. Hair-splitting distinctions between the exact limitations of groups of beds—however necessary in local and minor classifications—can have no decisive weight in the case, when the higher purpose of major classification, as an expression of the vital features of the history of the region, are duly considered.

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[1] Am. Geol., XXI, p. 229.